

INTRODUCTORY LESSONS

IN

ORGANIC

CHEMISTRY,

BY

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PREFACE.

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I have not intended these few chapters to be a treatise on organic chemistry, but have simply endeavored to lay the foundation upon which can be built a thorough knowledge of the subject.

The student of organic chemistry is very apt to discover that he is lost among numerous compounds with long names and complex composition without knowing from whence they come or how they are constructed.

Therefore to aid the student in better understanding the so called mysteries of organic chemistry these few pages are intended.

150 West 53rd Street, N. Y.

January, 1886.

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ORGANIC CHEMISTRY.

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CHAPTER I.

Organic chemistry treats of the chemistry of the carbon compounds.

The peculiarity of these compounds are, first, their extraordinary number; second, the few elements that enter into their composition, nearly all of them being formed by the union of carbon with hydrogen, nitrogen and oxygen; and lastly the large number of atoms contained in each molecule.

The cause of the multiplicity of these organic compounds is found in the peculiarity which carbon itself possesses of uniting with itself and other elements, especially nitrogen, oxygen and hydrogen, to form chemical combinations.

Thus for example carbon being a tetrad, it has four bonds to be satisfied by union with other bonds. If no free bonds remain

the compound is called *saturated*, if otherwise *unsaturated*. Not only may these free bonds become saturated by union with simple elements, but also with radicals, both simple and compound, thus greatly increasing the complexity of composition as well as the number of organic compounds.

Compounds are said to be *isomeric* when they have the same percentage composition, but differ in their chemical and physical properties.

Organic compounds form an *homologous series* when their general formulæ differ from one another by CH_2 , viz: by the replacement of a hydrogen by CH_3 . Thus the hydro carbon series CH_4 are homologous as each formula differs from the preceding one by CH_2 , and this series can therefore be expressed by the general formula, $\text{C}_n\text{H}_{2n+2}$ (n representing the number of atoms taken of each element to form the molecule.)

Organic chemistry may be divided into two great divisions called the *Fatty* and *Aromatic groups*; the fatty group being derived from methane (CH_4), and the Aromatic group from benzene (C_6H_6).

CHAPTER II.

FATTY GROUP.

HYDROCARBONS.

Compounds consisting of only carbon and hydrogen are called *hydrocarbons*. They form a number of interesting series, the compounds of each series differing from one another by CH_2 . These series start from the saturated compound methane (CH_4) and from which is derived the following homologous series, viz: By the addition of CH_2 , CH_4 , C_2H_6 , C_3H_8 , C_4H_{10} , C_5H_{12} , &c., and can be represented by the general formula $\text{C}_n\text{H}_{2n+2}$.

All of these homologous series represent saturated compounds, but by taking away from each formula one molecule or two atoms of hydrogen we have formed a number of homologous series whose general terms are expressed thus:— C_nH_{2n} , $\text{C}_n\text{H}_{2n-2}$, $\text{C}_n\text{H}_{2n-4}$, $\text{C}_n\text{H}_{2n-6}$, &c., and whose

compounds are unsaturated. These series are represented in the following table:—

$C_nH_{2n+2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4}, C_nH_{2n-6},$				
Methane.	Methene.			
$CH_4,$	$CH_2,$			
Ethane.	Ethene.	Ethine.		
$C_2H_6,$	$C_2H_4,$	$C_2H_2,$		
Propane.	Propene.	Propine.	Propone.	
$C_3H_8,$	$C_3H_6,$	$C_3H_4,$	$C_3H_2,$	
Butane.	Butene.	Butine.	Butone.	Butune.
$C_4H_{10},$	$C_4H_8,$	$C_4H_6,$	$C_4H_4,$	$C_4H_2, \&c.$

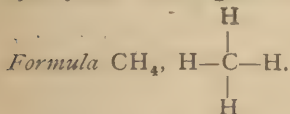
The name of each compound ends in *ne* with the prefix a, e, i, o or u, in order in each series, starting with a for the highest series (C_nH_{2n+2}).

CHAPTER III.

METHANE COMPOUNDS AND DERIVATIONS.

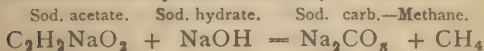
METHANE.

Synonyms. Marsh gas. Fire damp.



Occurrence. Methane occurs free in marshes and coal mines, and is the product of the slow decomposition of organic substances in the absence of oxygen.

Preparation. It is best prepared chemically by heating sodium acetate ($\text{C}_2\text{H}_3\text{NaO}_2$) with sodium hydrate (NaOH). Thus:—



Properties. Methane is a colorless, odorless gas, easily combustible and burning with a blue flame. It forms an explosive compound when mixed with air or oxygen.

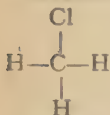
Use. It forms an important constituent of illuminating gas.

COMPOUNDS OF METHANE.

HALOGEN SUBSTITUTIONS.

By substituting halogen elements for one or more hydrogen atoms in methane we obtain a series of compounds called *Haloid ethers* among the most important of which are :—

METHYL CHLORIDE. CH_3Cl .



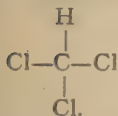
This compound does not occur free in nature, but is produced by the action of hydrochloric acid (HCl) upon methyl alcohol (CH_4O). It is a colorless gas with a sweetish taste.

METHYL BROMIDE. CH_3Br . This compound is prepared by the action of hydrobromic acid, (HBr) on methyl alcohol (CH_4O). It is a colorless liquid with an ether like odor.

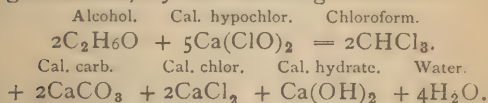
METHYL IODIDE. CH_3I . This is prepared like the above by the action of hydroiodic

acid (HI), upon methyl alcohol (CH_4O). It forms a colorless liquid which is easily decomposed on exposure to the light.

CHLOROFORM. CHCl_3 .



Chloroform is best prepared by the action of calcium hypochlorite, $\text{Ca}(\text{ClO})_2$ on common alcohol ($\text{C}_2\text{H}_6\text{O}$). The process is a complicated one, but can be expressed in a general way by the following formula:—



It is colorless liquid with a pleasant odor, but slightly combustible, burning with a green flame.

It is soluble in alcohol and ether, but slightly soluble in water. When perfectly pure it sinks readily in water without causing a troubling, and will not redden litmus paper.

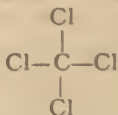
It is used principally as a solvent and an anæsthetic.

BROMOFORM. CHBr_3 . This is a colorless liquid with an odor like chloroform.

IODIFORM. CHI_3 . Iodiform is best prepared by the action of iodine on a solution of sodium carbonate (Na_2CO_3), in alcohol ($\text{C}_2\text{H}_5\text{O}$).

Thus prepared it is a yellowish crystalline flaky solid with saffron like odor. It is insoluble in water, but soluble in alcohol and ether. It is used principally in medicine.

CARBON TETRA CHLORIDE. CCl_4 .



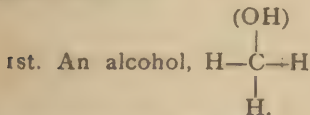
This compound is usually prepared from chloroform and is a colorless liquid with a pleasant odor.

CHAPTER IV.

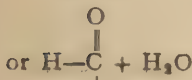
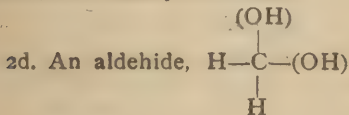
HYDROXYL SUBSTITUTION.

By substituting hydroxyl (OH) for one hydrogen in a hydrocarbon, an *alcohol* is produced, for two hydrogens an *aldehyde*, and for three hydrogens an organic *acid*.

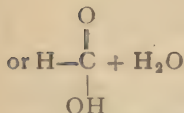
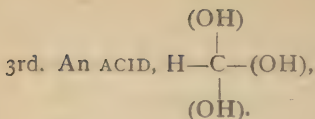
These substitutions can be represented as follows: Taking Methane (CH_4) as the hydrocarbon :—



$\text{CH}_3(\text{OH})$, Methyl ALCOHOL.



H. CH_2O Methyl ALDEHYDE.



CHO(OH) Formic acid.

COMPOUND ETHERS OR ESTERS are formed from *acids* by substituting for the hydroxyl hydrogen of the acid, hydrocarbon radicals or alcohol rests (alcohol minus hydroxyl). Thus by substituting for the hydroxyl hydrogen of formic acid CHO(OH), methyl (CH₃), there is formed methyl formic ether, CH₃, CHO₂.

Compound ethers are formed from *alcohol* by replacing the hydroxyl hydrogen of the alcohol by acid rests (acid minus hydroxyl.)

ETHERS are formed from alcohols by heating them with sulphuric acid (H₂ SO₄), and consist simply of two hydrocarbon radicals as methyl (CH₃) united by oxygen. Thus : CH₃—O—CH₃ is Methyl Ether.

Having now considered the formation of alcohols, acids, &c., we come to the study of

those connected with the methane compounds.

METHYL ALCOHOL, $\text{CH}_3 \text{OH}$.

Synonyms. Carbonal, wood spirits.

Preparation. It is obtained with crude acetic acid in the distillation of wood.

Properties. Methyl alcohol is a colorless mobile liquid with the odor and taste of common alcohol. It is combustible and has remarkable dissolving properties readily dissolving essential oils, varnishes, &c.

Uses. It is used principally in the manufacture of aniline dyes and as a solvent. Alcohols unite with acids to form *compound ethers* or *esters*, a molecule of water being given off.

Thus methyl alcohol (CH_3OH) with nitric acid (HNO_3) forms *methyl nitric acid* or *ether* (CH_3NO_3) and water.

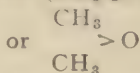
Methyl alcohol. Nit. acid. Methyl Nit. acid. Water.



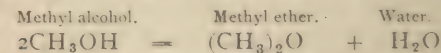
These esters are formed by simply replacing the hydroxyl hydrogen of alcohol with an acid rest (acid minus hydroxyl). Thus methyl alcohol with sulphuric acid (H_2SO_4) forms *methyl sulphuric acid* (CH_3O , HSO_3) or (CH_3 , HSO_4), with phosphoric acid (H_3

PO_4), *methyl phosphoric acid* ($\text{CH}_3, \text{H}_2\text{PO}_4$). If there remains a replaceable hydrogen in any of these esters, viz—a hydrogen in the acid rest as in the methyl sulphuric and phosphoric esters—the compounds are called acids or ester acids, and the hydrogens are replaceable with metallic elements as sodium and potassium forming *organic salts*. Thus *methyl sodium sulphate* has the formula $\text{CH}_3, \text{NaSO}_4$.

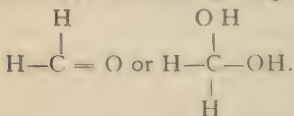
Methyl Ether $(\text{CH}_3)_2\text{O}$,



is obtained by heating methyl alcohol (CH_3OH) with sulphuric acid, the alcohol being split up into ether and water thus :

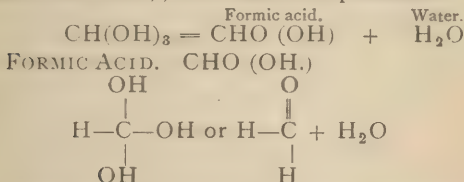


METHYL ALDEHYDE, CH_2O



Preparation. Methyl aldehyde is prepared by passing the vapor of methyl alcohol (CH_3OH) mixed with air over a heated platinum

spiral. If the oxidation is effected with stronger agents as sulphuric acid (H_2SO_4) and manganese dioxide (MnO_2) three hydrogens are replaced by OH and formic acid ($\text{CHO}(\text{OH})$) and water are produced.



Occurrence. It exists in nature in ants, pine needles, urine and blood. It also is a product of the decomposition of sugar, starch, gums, &c.

Preparation. Formic acid is best prepared by the decomposition of oxalic acid ($\text{C}_2\text{H}_2\text{O}_4$) in glycerine as thus represented.

Oxalic acid. Carbon-dioxide. Formic acid.



Properties. It is a colorless acid liquid soluble in water and alcohol. Its vapor is combustible. It is a good reducing agent, uniting with oxygen to form carbonic dioxide (CO_2) and water. Thus:



Salts of this acid can be formed by replacing one hydrogen (the hydrogen of the hydroxyl OH) by a metallic element as sodium, &c. Thus :--*sodium formate* has the formula CH, NaO_2 *lead formate* $(\text{CHO}_2)_2$ Pb. &c.

CHAPTER V.

OXYGEN SUBSTITUTIONS.

Oxygen may be substituted for the hydrogen in methane but as oxygen is a diad it will take two hydrogens to satisfy one oxygen.

CARBONYL, CO , $\text{<C} = \text{O}$.

Synonym, Carbon monoxide.

Carbonyl is a compound radical with an equivalence of two, and has been already treated of under inorganic chemistry. From it, organic compounds are formed by saturating its free bonds with other elements or compound radicals. Thus with sulphur it forms *Carbonyl sulphide* ($\text{S} = \text{C} = \text{O}$; with chlorine, *Carbonyl chloride*, $\text{Cl}-\text{C}=\text{O}$ (COCl_2) ;



with ammonogen (NH_2)

Urea $\text{NH}_2 - \text{C} = \text{O}$.



UREA, $\text{CH}_4\text{N}_2\text{O}$.

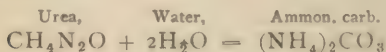
Synonym. Carbamide.

Occurrence. Urea is found in the urine of all mammalia and in small amount in many animal juices. It is the product of the oxidation of the nitrogenous elements of the body.

Preparation. It is best prepared by the decomposition of ammonium cyanide (NH_4, CNO) by heat as represented in the following equation :



Properties. Urea crystallizes in four-sided prisms and is soluble in water and alcohol. It has a bitter cooling taste like salt petre and is readily decomposed by heat setting free ammonia. Boiling with water, alkalies or acids the following decomposition takes place—



This decomposition also takes place spontaneously in urine, causing its alkaline fermentation.

Compounds. Urea combines with acids to form salts. Thus with nitric acid (HNO_3), it forms *nitrate of urea*, ($\text{CH}_4\text{N}_2\text{O}, \text{HNO}_3$) which is but slightly soluble in water.

hence urea can be readily separated from its solution by first converting it into the nitrate by the addition of nitric acid.

Compound ureas are formed by replacing one or more of the hydrogens in urea with hydrocarbon radicals as methyl (CH_3), ethyl (C_2H_5), &c., thus forming *methyl urca* ($\text{CH}_3\text{-N}_2\text{O-CH}_3$) *ethyl urca* ($\text{CH}_3\text{N}_2\text{O, C}_2\text{H}_5$), &c.

CARBON DIOXIDE. CO_2 .



This compound has been already studied in inorganic chemistry.

CHAPTER VI.

SULPHUR SUBSTITUTIONS.

As oxygen may take the place of hydrogens in methane in like manner sulphur may be substituted. If sulphur be substituted for one hydrogen, sulphur being a diad, *methyl sulphide* $(\text{CH}_3)_2\text{S}$ is produced; for two hydrogens *methyl sulphal-dehide* (CH_2S) , &c.

The most important compound of this group thus produced is carbon bi-sulphide CS_2 , all the hydrogens being replaced.

CARBON BI-SULPHIDE. CS_2 .

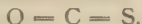


Preparation. Carbon bi-sulphide is best prepared by passing sulphur vapor over glowing coals the following reaction taking place $-\text{C} + \text{S}_2 = \text{CS}_2$.

Properties. It is a colorless liquid with a disagreeable odor and high refractive power. Insoluble in water. It has marked solvent properties, dissolving iodine bromine, phosphorous, oils, fats, &c.

Uses. It is used principally as a solvent, and in optics for its high refractive properties.

CARBON OXY-SULPHIDE. COS.



This compound stands in composition mid-way between carbon bi-sulphide (CS_2) and carbonic dioxide (CO_2).

Properties. It is an inflammable gas and easily decomposed by water into carbon dioxide and sulphuretted hydrogen. Thus:—

Carb. oxy. sulph. Water. Carb. diox. Sulph. hydrog.



SULPHONIC-ACIDS. These acids are produced by replacing the hydroxyl of sulphuric acid (H_2SO_4), with a hydrocarbon radical. Thus *methyl sulphonic acid* has the formula CH_3HSO_3 ; *Ethyl sulphonic acid*, $\text{C}_2\text{H}_5\text{HSO}_3$, &c.

CHAPTER VII.

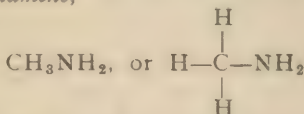
NITROGEN SUBSTITUTIONS.

The nitrogen derivatives of the hydrocarbons are numerous and important. From them are formed the *amines*, the *amides* and the *nitrils*.

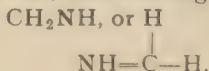
The hydrogens in methane may be replaced by the simple element nitrogen, which has an equivalence of three forming hydrocyanic acid, CHN, or

$$\begin{array}{c} \text{H} \\ | \\ \text{C} \equiv \text{N} \end{array}; \text{ by the}$$

compound radical NH_2 , called *amodogen*, which has an equivalence of one forming *methylamine*,



or by NH called *imodogen* which has an equivalence of two, thus forming

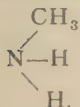


These compounds are much better understood by considering them as derived from ammonia (NH_3).

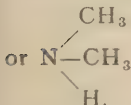
AMINES. An *amine* is a substituted ammonia with the hydrogens replaced by hydro-carbon radicals.

The amines may be primary, secondary or tertiary, depending upon the number of hydrogens replaced by the hydrocarbons. They resemble ammonia more or less, and unite directly with acids to form salts. Among the most important amines are—

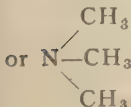
METHYLAMINE. CH_3NH_2 , or



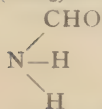
DI-METHYLAMINE. $(\text{CH}_3)_2\text{NH}$.



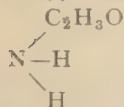
TRI-METHYLAMINE. $(\text{CH}_3)_3\text{N}$.



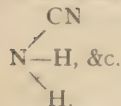
AMIDES are substituted ammonias in which the hydrogens are replaced by acid radicals (the acid minus the hydroxyl (OH).) Thus *formamide* CH_2, CHO is derived from formic acid $\text{CHO}(\text{OH})$, the acid radical CHO replacing one of the hydrogens in ammonia $(\text{NH}_3)-$



Acetamide, $(\text{NH}_2, \text{C}_2\text{H}_3\text{O})$ is derived in the same way from acetic acid $(\text{C}_2\text{H}_3\text{O}-(\text{OH}))$. Thus:—



as is also *cyanamide* (CN, NH_2) , derived from cyanic acid $(\text{CN}(\text{OH}))$ —



As the amines may be primary, secondary or tertiary, taking the prefixes mono, di or tri; so may the amides take like prefixes

as one, two or three of the hydrogens in ammonia are replaced by acid radicals.

IMIDES. We have so far only considered those substitutions for the hydrogens that have an equivalence of one, but two hydrogens in ammonia may be replaced by diad radicals, such compounds are called *imides*. Thus *carbimide* (NHCO) is such a compound and may be represented thus :



one hydrogen of the ammonia being replaced by the diad radical carbonyle (CO).

NITRILS. If all the hydrogens of ammonia are replaced by a triad radical we have a class of compounds called *nitrils*. Among the most important nitrils derived from methane is—

HYDROCYANIC ACID. HCN , $\text{N}\equiv\text{CH}$.

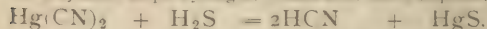
Synonym. Prussic acid.

Occurrence. It does not occur free in nature, but is the decomposition product of compounds found in the peach and cherry pits, flowers of the bitter almond, &c.

Preparation. It is best prepared by pass-

ing sulphuretted hydrogen (H_2S) over mercuric cyanide $\text{Hg}(\text{CN})_2$. Thus :—

Mercuric cyanide. Sulph. hydrogen. Prussic acid. Mercuric sulphide.



Properties. Prussic acid is a colorless liquid and the most active poison known.

It is soluble in water, alcohol and ether, and has an odor like peach blossoms. It unites with acids to form salts by the replacement of its hydrogen.

Compounds. Among the most important cyanides are *potassium cyanide* (KCN), *sodium cyanide* (NaCN), *ammonium cyanide* (NH_4CN), *mercuric cyanide* ($\text{Hg}(\text{CN})_2$), and the *iron cyanides*.

POTASSIUM CYANIDE, KCN .

Preparation. It is best prepared by adding hydrocyanic acid (HCN), to an alcoholic solution of potassium hydrate (KOH). Thus :—

Prussic acid. Pot. hydrate. Pot. cyanide. Water.



The potassium cyanide thus formed being insoluble in alcohol is precipitated.

Properties. Potassium cyanide crystallizes in cubes, but deliquesces on exposure to the air. In solution it decomposes rapidly

into an amorphous mass called *potassium formate* (CHKO_2), and ammonia NH_3 . Thus :—

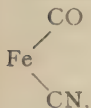
Pot. cyanide. Water. Pot. formide. Ammonia.



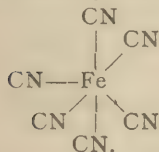
It has the odor and poisonous properties of hydrocyanic acid. It is also a powerful reducing agent taking up oxygen readily, thus forming *potassium cyanate* (KCNO).

IRON CYANIDES. These cyanides are seldom found in the separate state on account of their tendency to form double salts. The two principal cyanides of iron are the—

Ferrous cyanide. $\text{Fe}(\text{CN})_2$.



and *Ferric cyanide.* $\text{Fe}(\text{CN})_6$.



iron thus taking the equivalence of two or six.

Among the most important double salts are *potassium ferro cyanide* or yellow prussiate of potash $K_4Fe(CN)_6$, *potassium ferri cyanide* $K_6Fe_2(CN)_{12}$, called red prussiate of potash and *ferri-ferro cyanide*, $(Fe_2)_2 \cdot (Fe(CN)_6)_3$ or prussian blue.

CYANIC ACID. Beside the hydrocyanic acid (HCN), in which the hydrogen is united directly with cyanogen (CN) we have *cyanic acid* (HCNO), in which the hydrogen and cyanogen are united by means of oxygen. Thus: $CN-O-H$.

The hydrogen in this acid can be replaced by basic elements or radicals forming salts called *cyanates*, as for example *potassium cyanate* (KCNO), *ammonium cyanate* (NH_4 , CNO), *methyl cyanate* (CH_3 , CNO), &c.

SULPHO-CYANIC ACID. If the oxygen in cyanic acid be replaced by sulphur, *sulpho-cyanic acid* (CNHS) is produced, and from this acid the sulpho-cyanates are formed by replacing the hydrogen with basic elements or radicals. Thus for example we have *potassium sulpho-cyanate* (CNKS), *ammonium sulpho-cyanate* (CNS, NH_4), &c.

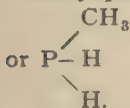
CHAPTER VIII.

PHOSPHORUS AND METALLIC SUBSTITUTIONS.

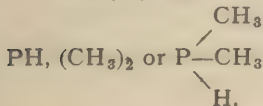
PHOSPHINES. If phosphorus is substituted for the nitrogen in the amine compounds a new group of compounds is obtained, called *phosphines*.

In the same way as was formed *mono*, *di*, and *tri-methylamine*, we now have by the substitution of phosphorus for the nitrogen, mono, di and tri methyl phosphine as thus represented :

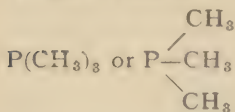
Methyl phosphine, PH_2CH_3 .



Di-methyl phosphine.

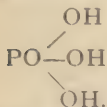


Tri-methyl phosphine.

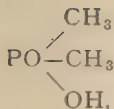


PHOSPHINIC ACIDS AND ETHERS.

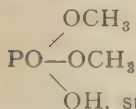
PHOSPHINIC ACID and ETHERS are obtained from phosphoric acid (H_3PO_4) the same way that nitro compounds are obtained from nitric acid (HNO_3), and sulphuric acids and ethers are obtained from sulphuric acid (H_2SO_4), viz: In the acid compounds by replacing the hydroxyl (OH) of the acid by a hydrocarbon radical as methyl (CH_3), and in the ether compounds by thus replacing the hydrogen only. *For example.* The hydroxyls of phosphoric acid (H_3PO_4) may be represented thus:—



Now if one or more of these hydroxyls are replaced by a hydrocarbon radical as methyl (CH_3), a methyl phosphinic acid is formed as *di-methyl phosphinic acid*,



but if the hydrogens alone are thus replaced a compound ether or ester is obtained as *di-methyl phosphonic ether*—

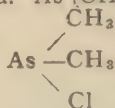


such esters are sometimes called ester acids, as one or more hydrogens still remain replaceable.

METALLIC DERIVATIVES.

One or more of the hydrogens in methane may be replaced by a metallic element thus forming a new set of compounds. For example *zinc methyl* has the formula $\text{Zn}(\text{CH}_3)_2$ —zinc being a diad it will take two methyl radicals to satisfy it. Arsenic being a triad *methyl arsenic* would have the formula, $\text{As}(\text{CH}_3)_3$ &c. But beside these single salts, double salts are formed by one or more of the bonds of the metallic element being saturated with other elements as chlorine.

Thus for example *di methyl arsenic chloride* would have the formula. $\text{As}(\text{CH}_3)_2\text{Cl}$ or

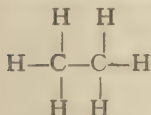


CHAPTER IX.

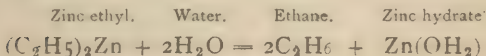
ETHANE COMPOUNDS.

Having considered the methane compounds we come to the next of the $C_nH_{2n} + 2$ series called ethane; and from it by taking away two hydrogens the unsaturated compound ethene or ethylene belonging to the C_nH_{2n} series and ethine or acetylene (C_2H_2) of the C_nH_{2n-2} series.

ETHANE, C_2H_6 or —

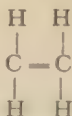


Preparation. It is best prepared by the action of water on zinc ethyl ($Zn (C_2H_5)_2$)
Thus :



Properties. Ethane is a colorless gas combustible and burning with a blue flame.

ETHYLENE, C_2H_4 .



Synonyms. Ethene or olifant gas.

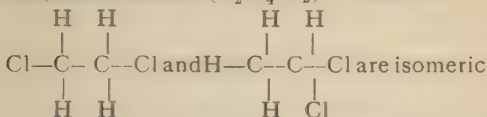
ACETYLENE, C_2H_2 .



Synonym. Ethine. Both of these compounds have already been considered in inorganic chemistry.

As ethane is formed by the union of two carbon radicals, and as the hydrogens of either one or both may be replaced by such elements as chlorine, it follows that there may be two isomeric series of compounds formed, having the same formula yet differing in construction. If only one hydrogen is replaced, isomerism is not possible, for the element occupies the same relative position in reference to C and H wherever it is placed; but if two hydrogens be thus replaced, the compounds resulting may be

constructed differently as is the case with ethylene chloride ($C_2H_4Cl_2$). Thus:—



compounds each having the same formula ($C_2H_4Cl_2$), but entirely different substances.

HALOGEN SUBSTITUTIONS.

One or more of the hydrogens in ethane may be replaced by the halogen elements, iodine, bromine or chlorine, thus forming ethyl iodide, bromide or chloride which may be either mono, di or tri.

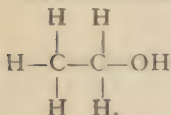
Among the most important of these compounds are *ethyl mono chloride* (C_2H_5Cl) *ethyl dichloride*, more commonly called *ethylene chloride* ($C_2H_4Cl_2$) *ethyl bromide* (C_2H_5Br) and *ethyl di bromide*, commonly called *ethylene bromide* ($C_2H_4Br_2$.) The ethyl chlorides are liquids having a pleasant odor while the bromides are crystalline solids.

CHAPTER X.

HYDROXYL SUBSTITUTIONS.

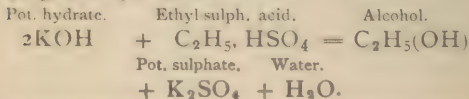
The formation of alcohols, aldehydes and acids, have already been explained (page 15) in considering the methane compounds, and as their formation is the same in all the hydrocarbon series, we now go on to examine them as applied to ethane compounds.

ETHYL ALCOHOL, $C_2H_5(OH)$,



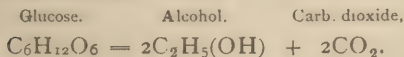
Synonym. Alcohol.

Preparation. Alcohol can be prepared chemically by the action of potassium hydrate (KOH), upon ethyl sulphuric acid C_2H_5, HSO_4 . Thus:—



Alcohol is made commercially by ferment-

ing grape sugar (glucose) with yeast, the grape sugar breaking up into alcohol and carbon di-oxide. Thus :—



Alcohol can be made from any material containing either starch or sugar, as rice, rye, corn, beets, grapes, &c. By the addition of water, cane sugar ($C_{12}H_{22}O_{11}$) and starch ($C_6H_{10}O_5$) are both converted into glucose ($C_6H_{12}O_6$). The alcohol thus obtained by fermentation is not pure, but contains other alcohols, especially amyl alcohol and water.

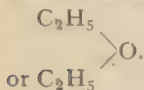
The water may be gotten rid of by distillation, the boiling point of alcohol being much below that of water.

Properties. Alcohol is a colorless mobile fluid with an ether-like odor. It boils at $85^\circ C.$, but does not freeze.

It is combustible, burning with a very hot but slightly luminous flame.

It absorbs moisture readily, and extracts the water of crystallization, from many salts. It has marked solvent properties readily dissolving iodine, bromine, fats, oil, resins, &c. By uniting with acids alcohol

forms compound ethers. With sulphuric acid (H_2SO_4), it forms *ethyl sulphuric acid* or *ester* ($\text{C}_2\text{H}_5, \text{HSO}_4$), with nitric acid (HNO_3), *ethyl nitric ether* ($\text{C}_2\text{H}_5, \text{NO}_3$), &c. Salts are formed from these acids by replacing the hydrogen of the acid with basic elements as potassium, thus forming with ethyl sulphuric acid, *ethyl potassium sulphate* ($\text{C}_2\text{H}_5\text{KSO}_4$). If alcohol is heated with sulphuric acid it forms (see methyl ether),
 SULPHURIC ETHER, $\text{C}_4\text{H}_{10}\text{O}$.



Synonym. Ether.

Preparation. Ether is made by heating nine parts of sulphuric acid (H_2SO_4) with five parts of alcohol.

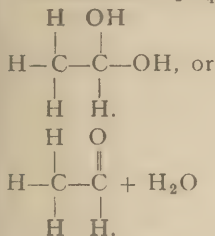
Ethyl sulphuric acid ($\text{C}_2\text{H}_5, \text{HSO}_4$), is first produced but is afterward decomposed, splitting up into ether and sulphuric acid. The ether is distilled off with some of the alcohol, and is freed from the latter with caustic lime $\text{Ca}(\text{OH})_2$.

Properties. Ether is a colorless mobile liquid with a pleasant odor, producing in-

sensibility when inhaled. It is combustible, burning with a luminous flame.

Uses. It is used as a solvent and as an anæsthetic.

ALDEHIDE, C_2H_4O .



Synonym. Ethyl aldehyde.

Preparation. It is best prepared by the action of chromic acid (H_2CrO_4), on alcohol.

Properties. Aldehyde is a colorless, mobile liquid with a suffocating odor. It is soluble in ether and combustible.

Compounds. Chlorine can be substituted for one or more of the hydrogens in aldehyde forming compounds, the most important of which is—

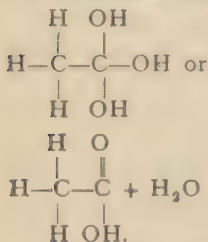
CHLORAL, C_2HCl_3O .

Preparation. Chloral is best prepared by the action of chloroform upon alcohol, the

alcohol first being converted into aldehyde and afterward into chloral.

Properties. It exists as a colorless liquid, which added to water forms *chloral hydrate* ($C_2HCl_3O \cdot H_2O$), a transparent crystalline substance having a peculiar odor and biting taste. It is used extensively in medicine.

ACETIC ACID, $C_2H_3O(OH)$.



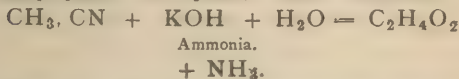
Synonym. Vinegar.

Occurrence. It is found in many plants and fruits, also in some of the secretions of animals.

Preparation. Acetic acid is prepared by the oxidation of alcohols, (acetic fermentation,) by the distillation of wood, and chemically

by the action of potassium hydrate (KOH) upon methyl cyanide (CH_3, CN). Thus:—

Methyl cyanide. Pot. hydrate. Water. Acetic acid.



Properties. At ordinary temperature, acetic acid is a colorless liquid having a sharp odor and caustic properties. As it has one replaceable hydrogen (that of the hydroxyl OH), it is mono basic and unites readily with bases to form salts among the most important of which are *potassium acetate* ($\text{KC}_2\text{H}_3\text{O}_2$), *plumbic acetate* so called “sugar of lead,” ($\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$) and *cupric acetate* or “verdigris” ($\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$).

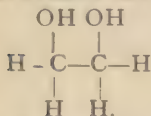
CHAPTER XI.

HYDROXYL SUBSTITUTIONS—(CONTINUED.)

GLYCOLS, &C.

We have so far only considered those alcohols, aldehydes and acids in which the hydrogens of one hydro carbon radical forming ethane have been replaced by hydroxyl.

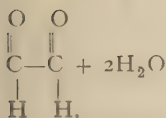
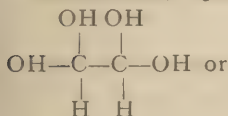
If, however, the hydrogens of both radicals be replaced by hydroxyl we have formed a new set of alcohols aldehydes and acids. Alcohols thus formed are called *glycols*, and the one formed from ethane—ETHYLENE GLYCOL, $C_2H_4(OH)_2$.



Properties. It is a colorless odorless liquid, quite easily decomposed by oxidation into *glycollic acid* $C_2H_4O_3$, which exists in the form of a white deliquescent mass. This acid has one replaceable hydrogen and

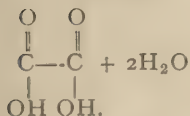
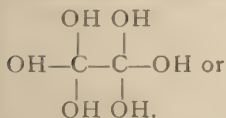
forms salts by its union with basic elements, such as calcium, forming *calcium glycollate* ($\text{Ca}(\text{C}_2\text{H}_3\text{O}_3)_2$).

GLYCOLLIDE, $\text{C}_2\text{H}_2\text{O}_2$.



is the aldehyde of this order, and oxalic acid the corresponding acid.

OXALIC ACID, $\text{C}_2\text{O}_2(\text{OH})_2$.



Occurrence. It occurs in many vegetables and fruits in the form of oxalates.

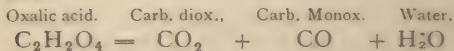
Preparation. It is best prepared by melting saw dust with potassium hydrate (KOH.)

Properties. Oxalic acid as thus prepared crystallizes in transparent prisms.

It is soluble in water and alcohol and is very poisonous.

It readily decomposes by heat into water, carbon dioxide (CO₂) and monoxide (CO).

Thus:



Compounds. Oxalic acid is di basic having two replaceable hydrogens (C₂O₂(OH)₂) and therefore unites with basic elements to form either acid or neutral salts. Among the most important of these salts are *potassium oxalate* (K₂C₂O₄), *acid potassium oxalate* or *potassium hydro-oxalate* (KHC₂O₄), *calcium oxalate* (CaC₂O₄) &c.

By replacing one or both of the hydrogens with hydrocarbon radicals as ethyl (C₂H₅) or methyl (CH₃) oxalic acids or esters are formed. Thus we have by the replacement of one hydrogen with ethyl, *ethyl oxalic acid* (C₂H₅,C₂HO₄) of both hydrogens, *ethyl oxalic ester* or ether (C₂H₅)₂, C₂O₄.

CHAPTER XII.

SULPHUR AND OTHER SUBSTITUTIONS OF ETHANE.

SULPHUR SUBSTITUTIONS.

The sulphur substitutions of ethane not very important but among which are *ethyl sulphide* $(C_2H_5)_2S$, a colorless liquid having a garlic like odor; and *ethyl sulphaldehyde* (C_2H_4S) a substance corresponding in composition to ethyl aldehyde, viz: two of the hydrogens in ethane being replaced by sulphur instead of the hydroxyl (OH).

NITROGEN SUBSTITUTIONS.

AMINES. By substituting for one or more hydrogens in ammonia (NH_3) the hydrocarbon radical ethyl (C_2H_5) we have formed *mono, di or tri ethylamine* $(C_2H_5NH_2$; $(C_2H_5)_2NH$ and $(C_2H_5)_3N$).

In the same way ethylene amine compounds are formed by replacing the ammonia hydrogens with the compound radical ethylene (C_2H_4) which has an equiva-

lence of two. Thus *ethyline diamine* has the formula $(C_2H_4(NH_2)_2)$, *di ethylene diamine* $(C_2H_4)_2(NH)_2$ &c.

AMIDES. By substituting for one of the hydrogens of ammonia the acid radical of acetic acid $C_2H_3O(OH)$ we have produced *acetamide* (C_2H_3O, NH_2) a colorless crystalline substance with a peculiar odor. In the same way by substituting the acid radical of oxalic acid $C_2O_2(OH)_2$ (oxalic acid having two replaceable hydrogens hence dibasic) *oxamide* $(C_2O_2(NH_2)_2)$ is produced.

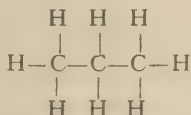
PHOSPHOROUS AND METALLIC SUBSTITUTIONS.

As methyl phosphine (CH_3PH_2) is formed from phosphoric acid (H_3PO_4) by methyl substitutions so in the same way is produced by the substitution of ethyl, *ethyl phosphine* $(C_2H_5PH_2)$, *di ethyl phosphine* $(C_2H_5)_2PH$, &c. Ethyl having an equivalence of one will by uniting with zinc form *zinc ethyl*, $C_2H_5)_2Zn$ with arsenic, *tri ethyl arsine* $(C_2H_5)_3As$; with mercury, *mercury ethyl* $(C_2H_5)_2Hg$, &c.

CHAPTER XIII.

PROPANE COMPOUNDS.

Propane compounds are those derived from propane—(C_3H_8) which is formed by the union of three hydro-carbon radicals, thus :—



Of *propane* but little is known. It belongs to the $C_nH_{2n} + 2$ series.

By the extraction of H_2 there is produced a compound belonging to the next series C_nH_{2n} called *propine* or *propylene* (C_3H_6) which exists in the form of a gas. By again extracting H_2 we obtain a compound belonging to the next series C_nH_{2n-2} called *propine* or *allylene* (C_3H_4) which also exists in the form of a gas. As propane is formed by the union of three radicals, it admits of three series of isomeric compounds.

HALOGEN SUBSTITUTIONS.

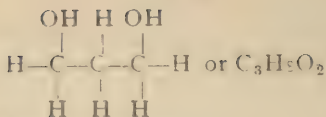
If a halogen element be substituted for hydrogen in one of the hydro-carbon radicals forming propane propyl compounds are produced the most important of which is *propyl iodide* (C_3H_7I).

If substituted for the hydrogens in two of the radicals the compounds resulting are called propylene as *propylene iodide* ($C_3H_6I_2$) and if substituted for the hydrogens in all three radicals we have allylene compounds as *allylene bromide* $C_3H_4Br_3$. As there are more than one hydrogen in each of the radicals these compounds thus formed may be mono, di or tri depending upon the number of hydrogens replaced.

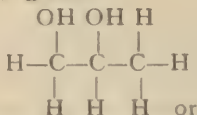
CHAPTER XIV.

HYDROXYL SUBSTITUTIONS.

As there are three hydro-carbon radicals forming propane and the hydrogens of either one, two or three may be replaced by hydroxyl we have formed three sets of alcohols, aldehydes and acids. In the first set the hydrogens of only one radical are replaced, in the second set those of two radicals and in the third set those of all three radicals. Many of these alcohols, aldehydes and acids are isomeric—having the same chemical formula but differing in their physical and chemical properties. Thus isomerism depends upon the fact that the hydrogens in either of the hydro-carbon radicals forming propane may be replaced by hydroxyl thus giving the same chemical formula but entirely different substances. Thus for example there are two propyl glycols (alcohols) one, normal propyl glycol,—



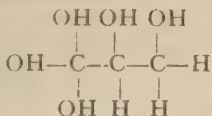
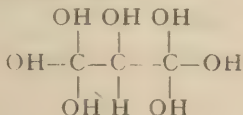
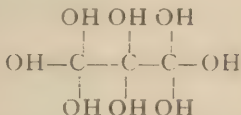
and isopropyl glycol,



$\text{C}_3\text{H}_5\text{O}_2$, their difference simply depending upon which radical has its hydrogen replaced by OH.

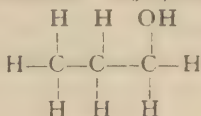
This isomerism is not limited to hydroxyl substitutions but to all substitutions in the hydro carbon compounds consisting of more than one carbon. In the formation of these three sets of acids, three hydrogens of one hydro-carbon radical must be replaced by OH, but only one or all of the hydrogens in the other radicals need be thus replaced.

Thus *for example* in the third set of acids in which one or more of the hydrogens in all three radicals are replaced, by hydroxyl, three acids are formed depending upon the number of hydrogens replaced as

1st. *Glyceric acid*2nd. *Tartronic acid*3rd. *Misoxal acid*.

We now come to the consideration of the first set of compounds in which the hydrogens of only one radical are replaced by hydroxyl. The principal alcohol of this group is

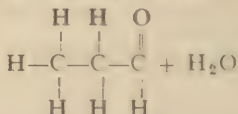
PROPYL ALCOHOL. $\text{C}_3\text{H}_7(\text{OH})$



Preparation. It occurs in small amount in the alcoholic fermentation of sugar.

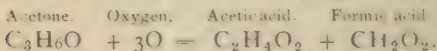
Properties. It is a liquid with an ether like odor, easily oxidized into the aldehyde of the first class.

ACETONE or *ketone*, C_3H_6O .

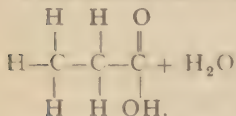


Preparation. It is prepared by the dry distillation of sugar, starch or salts of acetic acid ($C_2H_4O_2$).

Properties. It is a colorless liquid with a disagreeable odor, breaking up upon oxidation into formic acid, acetic acid. Thus:



PROPRIONIC ACID, $C_3H_5O(OH)$.



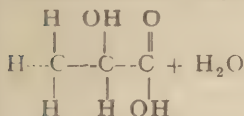
Occurrence. It is found in the blossoms of plants and in some animal secretions, as sweat.

Preparation. It can be prepared by the oxidation of propyl alcohol or by boiling ethyl cyanide (C_2H_5CN) with potassium hydrate (KOH).

Properties. Propronic acid is a liquid having the odor and taste of vinegar. It is a mono basic acid and forms salts and esters by substituting for the hydrogen, basic elements or hydrocarbon radicals.

PROPYL GLYCOL ($C_3H_6(OH)_2$), is an alcohol belonging to the second class, and lactic acid the principal acid.

LACTIC ACID, $C_3H_5O_2(OH)$.



Occurrence. It occurs in sour milk and in the juices of many plants. It is also the product of lactic fermentation of sugar.

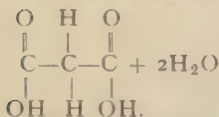
Preparation. Lactic acid is best prepared by allowing a solution of sugar to stand several days with putrid cheese and chalk. Calcium lactate $Ca(C_3H_5O_3)_2$ is formed which, when acted upon by sulphuric acid (H_2SO_4), lactic acid is set free.

Properties. It is a syrupy liquid with a

very sour taste. Upon distillation it gives off two molecules of water, forming *lactide* ($C_6H_8O_4$).

Compounds. Lactic acid is mono basic, and by union with basic elements forms salts as *magnesium lactate* $Mg(C_3H_5O_3)_2$, *potassium lactate* ($KC_3H_5O_3$), *Zinc lactate* $Zn(C_3H_5O_3)_2$, &c. By substituting for the hydrogen of the hydroxyl, hydrocarbon radicals, esters are formed, as *ethyl lactic ester* ($C_2H_5-C_3H_5O_3$). By substituting for the hydroxyl NH_2 , we have the formation of *lactamide* ($NH_2, C_3H_5O_2$).

MALONIC ACID, $C_3H_2O_2(OH)_2$.

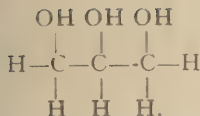


This is another acid belonging to the second class.

It is crystalline, soluble in water and di-basic in character, forming with basic elements acids and neutral salts.

There is but one alcohol of the third class and that is—

GLYCEROL, $C_3H_5(OH)_3$.



Synonym. Glycerine.

Occurrence. It is found in nearly all vegetable and animal fats. A little occurs also with the alcoholic fermentation of sugar.

Preparation. It is best prepared by decomposing fats with super-heated steam.

Properties. Glycerine is a colorless syrupy liquid with a sweetish taste, soluble in water and not easily decomposed when pure.

If glycerine is mixed with nitric acid (HNO_3) in the presence of sulphuric acid (H_2SO_4), it forms *nitro glycerine* or *glycol nitric ester*, $\text{C}_3\text{H}_5(\text{NO}_3)_3$, a violently explosive substance. When mixed with infusorial earth it is called *dynamite*. Fats and oils are glycerol esters or glycerides.

ACIDS. There are three acids belonging to the third class, their composition depending upon the number of hydrogens replaced by hydroxyl, none of which, however, are of much importance.

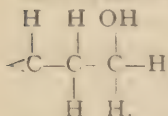
CHAPTER XV.

HYDROXYL SUBSTITUTIONS.

(CONTINUED.)

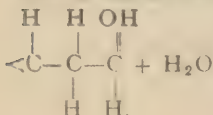
By substituting hydroxyl for the hydrogen of the unsaturated hydrocarbon C_3H_6 of the C_nH_{2n} series we get a new group of compounds called *allyl*, some of which are obtained from *allyl iodide* C_3H_5I .

ALLYL ALCOHOL, $C_3H_5(OH)$.



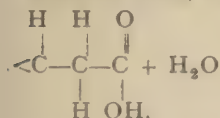
This is a colorless liquid with a biting odor and taste. It is combustible, burning with a hot flame.

ALLYL ALDEHYDE or *acrolein*, C_3H_4O or



This is an oily liquid with a nasty odor and taste. It readily decomposes.

ACRYLIC ACID, $C_3H_3O(OH)$.



Acrylic acid is mono-basic and has a very peculiar disagreeable odor. Its salts are mostly crystalline, the most important of which is *sodium acrylate* ($\text{NaC}_3\text{H}_3\text{O}_2$.)

There are two important oils belonging to the allyl compounds--mustard oil and garlic oil.

Mustard oil, C_3H_5 , NCS is produced from mustard seeds by fermentation.

It is a clear liquid, having the properties of mustard.

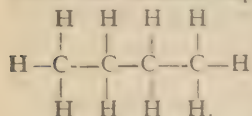
Garlic oil or *allyl sulphide* $(C_3H_5)_2S$ is found in nature in the bulbs of garlics and onions.

It is a clear liquid with a garlic like odor.

CHAPTER XVI.

BUTANE COMPOUNDS.

The next of the hydrocarbon series with the general formula C_nH_{2n+2} is *Butane* (C_4H_{10}), which is a compound of four hydrocarbon radicals expressed thus:—



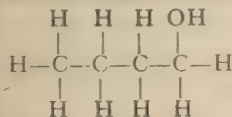
As the hydrogens in any of these four radicals can be replaced by halogens, hydroxyl, &c., many of the resulting compounds are isomeric, as *butyl chloride* (C_4H_9Cl) and *isobutyl chloride* (C_4H_9Cl). The halogen substitutions of butane are numerous but unimportant.

HYDROXYL SUBSTITUTIONS.

As there were three sets of alcohols, aldehydes and acids formed from propane by hydroxyl substitutions so there are four sets thus obtained from butane.

The most important alcohol thus obtained from butane is

ISOBUTYL ALCOHOL, $C_4H_9(OH)$.

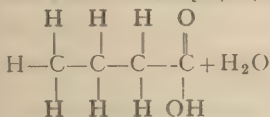


Occurrence. It occurs in the alcoholic fermentation of sugar but in a small amount.

Properties. It is a clear liquid with a sharp biting taste and has an odor resembling fusel oil.

The *aldehydes* of butane are of little importance but many of the acids are well known.

BUTYRIC ACID, $C_4H_7O(OH)$.



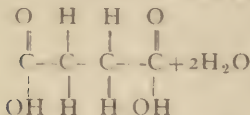
Occurrence. It occurs with other acids in butter in sweat and in the juices of some plants.

Preparation. It is prepared from the lactic acid fermentation of sugar in a process similar to that of the preparation of lactic

acid except that the fermentation is allowed to proceed further.

Properties. Butyric acid is a colorless sour liquid with an odor resembling vinegar. It is mono-basic in character forming crystalline salts by its union with basic elements.

SUCCINIC ACID. $C_4H_4O_2(OH)_2$

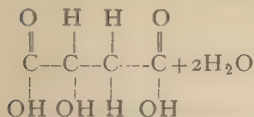


Occurrence. This acid occurs in many plants, in some of the animal secretions and in amber. It is also a product of the alcoholic fermentation of sugar.

Preparation. It is prepared by the distillation of amber.

Properties. Succinic acid crystallizes in prisms. It is soluble in water and has a biting taste. It is di-basic in character forming acid or neutral salts by the replacement of one or both hydrogens with basic elements.

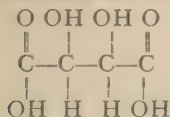
MALIC ACID, $C_4H_4O_3(OH)_2$



Occurrence. It occurs in many sour fruits and is usually prepared from the ripe berries of the mountain ash.

Properties. Malic acid crystallizes at ordinary temperatures in a solid mass. It is soluble in water and has a very sour taste. It is di-basic in character forming neutral and acid salts.

TARTARIC ACID, $C_4H_4O_4(OH)_2$.



Occurrence. It occurs in many fruits especially grapes.

Preparation. Acid tartrates of calcium and potassium occur in solution in young wine but as the wine grows stronger in alcohol these acid salts which are insoluble in alcohol are deposited on the sides of the wine casks. From these masses called *argol*

or *tartar* the tartaric acid is prepared. It is also artificially produced by the action of nitric acid (HNO_3) on sugar of milk ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$)

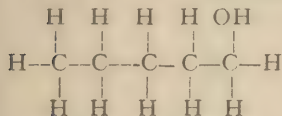
Properties. Tartaric acid occurs in crystals but is easily soluble in water. It has a sour pleasant taste and being di-basic forms acid and neutral salts some of which are very important. Among the most important tartrates are *acid potassium tartrate* or "cream of tartar" ($\text{C}_4\text{H}_5\text{KO}_6$) *potassium tartrate* ($\text{C}_4\text{H}_4\text{K}_2\text{O}_6$) and *potassium antimonial tartrate* ($2\text{KSb}(\text{OC}_4\text{H}_4\text{O}_6)$)

CHAPTER XVII.

PENTANE COMPOUNDS.

The next of the saturated series C_nH_{2n+2} is *pentane* or *amyl* C_5H_{12} and consists of the union of five hydro-carbon radicals. There are but few compounds belonging to this group of any importance. Among them are amyl alcohol and valerianic acid.

AMYL ALCOHOL, $C_5H_{11}(OH)$

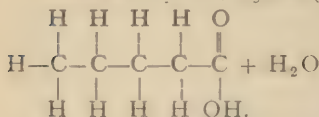


Synonym. Fusel oil.

Occurrence. It occurs in the alcoholic fermentation of sugar and is separated by distillation.

Properties. Fusel oil is a colorless liquid with a burning raw taste and disagreeable odor. It is combustible, burning with a hot flame.

VALERIANIC ACID, $C_5H_9O(OH)$.



Occurrence. It occurs in the root of the plant valerian from which it is prepared, and also in putrid cheese.

Properties. It is a liquid with the odor of rotten cheese and is used extensively in medicine.

It is mono-basic in character, forming salts, the most important of which is *zinc valerianate*, $Zn (C_5H_9O_2)_2$.

URIC ACID, $C_5H_4N_4O_3$. This acid probably belongs to the pentane group, but is of complicated composition.

Synonym. Lithic acid.

Occurrence. It forms a normal constituent of urine and is usually prepared from the urine of snakes, which is composed almost entirely of uric acid.

Properties. Uric acid exists in the form of a white crystalline powder slightly soluble in water. It has two replaceable hydrogens, consequently is di-basic in character

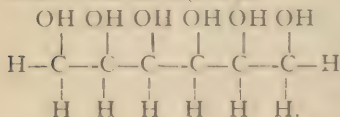
forming neutral and acid salts, the most important of which are *sodium urate* ($C_5N_4H_2Na_2O_3$), and *acid potassium urate* ($C_5N_4H_3KO_3$). Uric acid has many derivatives.

CHAPTER XVIII.

HEXANE COMPOUNDS.

Hexane compounds are not well known or understood. There are several important compounds, among this group, however, as hexyl alcohol or mannite and citric acid.

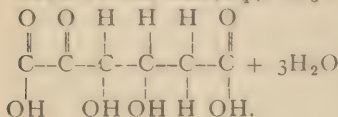
MANNITE, $C_6H_8(OH)_6$.



Occurrence. It occurs in large quantities in the vegetable kingdom, especially in "manna," the dried sap of *flaximus ornus*.

Properties. It stands in close relation to sugar. It has a sweet taste, crystallizes in prisms, and is soluble in water.

CITRIC ACID, $C_6H_5O_4(OH)_3$.



Occurrence. It occurs in many sour fruits, especially the lemon, from which it is prepared.

Properties. It exists in crystalline masses which are slightly deliquescent. It is soluble in water and has a sour pleasant taste. In solution it readily decomposes.

It is tri-basic forming salts, the most important of which are *calcium citrate*, $\text{Ca}_3(\text{C}_6\text{H}_5\text{O}_7)_2$ *magnesium citrate* $\text{Mg}_3(\text{C}_6\text{H}_5\text{O}_7)_2$ and *ferric citrate* $\text{Fe}_2(\text{C}_6\text{H}_5\text{O}_7)_2$.

CHAPTER XIX.

OILS AND FATS.

There are many higher hydrocarbon compounds of the C_nH_{2n+2} series than hexane, but most of them are unimportant.

There are several acids, however, belonging to these higher series which are of importance as they occur in oils and fats. These are *palmetic acid*, $C_{16}H_{31}O(OH)$, *stearic acid* $C_{18}H_{35}O(OH)$, both of which are solid at ordinary temperatures, and *oleic acid* $C_{18}H_{33}O(OH)$ a liquid.

FATS and OILS are mostly glycerol esters of these acids, and their composition may be represented by substituting for the hydroxyl hydrogen of glycerol, $C_3H_5(OH)_3$ the acid rests of palmetic, stearic and oleic acids.

The following important glycerol esters or fats are thus obtained:—

Palmitin, $C_3H_5(C_{16}H_{31}O_2)_3$.

Stearin, $C_3H_5(C_{18}H_{35}O_2)_3$.

Olein, $C_3H_5(C_{18}H_{33}O_2)_3$.

In the vegetable fats olein is the most important and is fluid at ordinary tempera-

tures. It occurs in olive oil, almond oil, coconut oil, castor oil, croton oil, &c.

All three of the fats occur in animals.

Butter is a glyceride or ester of butyl and other acids.

All fats are decomposed by alkalies into fatty acids and glycerine. The fatty acids combine with the alkalies to form salts.

These fatty acid salts of potassium and sodium are called *soaps*. *Soft soap* is potash soap, and *hard soap* is soda soap.

SPERMACETI is the palmetic ester of cetyl alcohol $C_{16}H_{33}(OH.)$

CHAPTER XX.

CARBOHYDRATES.

Carbohydrates are hydrocarbons, mostly belonging to the hexane compounds containing hydrogen and oxygen in proportion to form water.

They may be divided into *three* groups. The *first* group comprising grape sugar, fruit sugar and galactose have the general formula $C_6H_{12}O_6$.

The *second* group comprising cane sugar, lactose and melitose have the formula $C_{12}H_{22}O_{11}$; and the *third* group starch, cellulose, dextrine, glycogen and mucilage, the formula $C_6H_{10}O_5$.

All the carbohydrates are soluble in water, bend the flame of polarized light, decomposed by heat, leaving carbon and converted by oxidation into oxalic acid ($C_2H_2O_4$.)

GRAPE SUGAR, $C_6H_{12}O_6$.

Synonyms. Glucose, dextrose.

Occurrence. It occurs in nearly all sweet fruits and in honey.

Preparation. It is made from the fruits and chemically by boiling cane sugar with dilute acids.

Properties. Grape sugar as first obtained is a syrupy liquid, but crystallizes on standing. It is soluble in water and has a sweet taste. It turns the plane of polarized light toward the right and is fermentable.

When boiled with an alkaline solution of cupric sulphate (Cu_2SO_4) the copper becomes oxidized and is precipitated as the red oxide of copper (Cu_2O).

This reaction forms a delicate test for the presence of glucose.

Levulose. $\text{C}_6\text{H}_{12}\text{O}_6$.

Synonym. Fruit sugar.

Its occurrence, preparation and properties are the same as glucose, but can be distinguished from it by turning the plane of polarized light toward the left, and being less easily crystallized.

Galactose. $\text{C}_6\text{H}_{12}\text{O}_6$.

Preparation. It is prepared by boiling milk sugar with dilute acids. Its properties are the same as glucose.

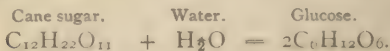
CANE SUGAR. $C_{12}H_{22}O_{11}$.

Synonym. Saccharose.

Occurrence. It occurs principally in the juices of sorghum, sugar cane, sugar beet and maple, and prepared from them by evaporation.

Properties. It crystallizes, is soluble in water, has a very sweet taste and polarizes toward the right.

By heating with dilute acids it takes up water and is converted into glucose. Thus :—



LACTOSE. $C_{12}H_{22}O_{11}$.

Synonym. Milk sugar.

Occurrence. It occurs in mammals milk, from which it is prepared.

Properties. It crystallizes in rhombic shaped prisms, is soluble in water and has a sweet taste, having the general properties of cane sugar.

STARCH. $C_6H_{10}O_5$.

Synonym. Amylum.

Occurrence. It occurs abundantly throughout the vegetable kingdom, but is found

especially in grains and potatoes from which it is prepared.

Properties. It consists of fine white granules, their shape depending upon the kind. It is without taste and insoluble in cold water.

It is converted first into dextrine and then into glucose by dilute acids, by dry heat and by *diastase* (a ferment in germinating grain.) Iodine unites with starch in solution, forming a deep blue color, thus affording a delicate test for amylum.

Glycogen. $C_6H_{10}O_5$.

Occurrence. It occurs in all livers from which it is prepared.

Properties. Glycogen is a yellowish white powder, soluble in water and changed into glucose by dilute acids and ferments. With iodine it turns a claret color.

DEXTRINE. $C_6H_{10}O_5$.

Synonym. British gum.

Preparation. It is prepared from starch by adding dilute nitric acid (HNO_3), and then rapidly drying.

Properties. Dextrine is an amorphous white substance without any reaction with

iodine, soluble in water and rapidly converted into glucose by means of ferments and acids.

CELLULOSE. $C_6H_{10}O_5$.

Synonym. Woody fibre, cotton.

Occurrence. It forms the skeleton and plant cells of wood and plants.

Properties. As usually prepared it is a white mass, insoluble in water. When dissolved with sulphuric acid H_2SO_4 , and precipitated by the addition of water it is called *amyloid*. It is this amyloid that gives the peculiar appearance to "parchment paper." If cellulose (cotton) be treated with one part nitric acid (HNO_3), and three parts sulphuric acid (H_2SO_4), a violent explosive called *gun cotton* $C_5H_7(NO_3)_3O_5$, is formed.

Gun cotton dissolved in ether is called *collodion*.

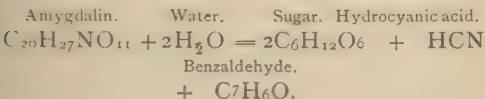
GLUCOSIDES. There is a large number of substances occurring in the vegetable kingdom closely allied to the carbohydrates called *glucosides*. They are usually compounds of dextrose combined with one or more other organic substances.

By boiling with dilute acids, alkalies, or by ferments they split up into sugar, and

the other constituents of which they are composed.

Amygdalin, $C_{20}H_{27}NO_{11}$ is the glucoside found in bitter almonds, cherry and peach pits, &c., and can be split up by the ferment—*emulsion* into its constituents, dextrose, hydrocyanic acid and benzaldehyde.

Thus:—



CHAPTER XXI.

FERMENTATION.

Some substances when undergoing decomposition or decay, have the property of setting up decomposition in other substances when added to them. The decaying substance is called a *ferment*, the substance decomposed *fermentable*, and the process *fermentation*.

Different ferments set up different kinds of fermentation, but do not themselves add any elements to the products of fermentation.

If the products of fermentation are sweet-smelling the process is called pure fermentation, but if accompanied by foul odors putrefaction.

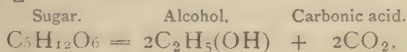
Ferments are of two kinds, decomposable organic compounds and organized bodies. Belonging to the first-class are albuminous substances as *diastase*, a substance formed from germinating grain from the decomposition of gluten; *emulsin* a substance occurring in almonds; and the *animal ferments*

occurring in animal secretions, as saliva, pancreatic and gastric juices, &c.

Belonging to the second class of organized ferments are the *yeast plant* and *lactic acid ferment*, &c. As most ferments are vegetable growths they must be supplied with proper food for their development. This food is found in the albuminous principles occurring in the fermentable substance.

Most ferments require for their development oxygen, and a temperature between 40° and 90° F. Some substances undergo spontaneous fermentation, but this is due to the *sporules* or seeds of the ferment which float in the air finding their way into these substances and then propagating.

There are five principal fermentations—*alcoholic*, *acetic*, *lactic*, *butyric* and *mucus*, the most important of which is the alcoholic. The alcohol ferment is yeast, the fermentable substance sugar, and the principal products of fermentation, alcohol and carbonic acid gas. Thus:—

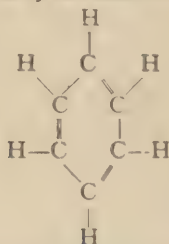


CHAPTER XXII.

AROMATIC GROUP OF ORGANIC COMPOUNDS.

As the *fatty group* of compounds was derived directly or indirectly from *methane* (CH_4), so has the *aromatic group* also a starting point in *benzine* (C_6H_6).

BENZINE is supposed to belong to the unsaturated group of hydrocarbons having the general formula $\text{C}_n\text{H}_{2n-6}$, and graphically expressed by the chain or ring formula



As one or more hydrogens in methane can be replaced by halogens, hydroxyl, acid radicals, amidogen, &c., so may the hydrogens in benzine be likewise replaced. It is a curious fact however if only one hydrogen in

benzine be thus replaced by elements or atomic groups, but one compound can be formed, in other words one hydrogen substitution allows of no isomerism. This does not hold true however if two or more hydrogens be thus replaced.

BENZINE, C_6H_6 .

Synonym. Benzol.

Preparation. All organic compounds heated to a red heat yield benzine, hence it is formed in the manufacture of illuminating gas and obtained from the coal tar by distillation.

Properties. Benzine is a clear liquid with an aromatic odor and taste. It has a low boiling point and is readily combustible, burning with a very smoky yellow flame.

It has strong refractive properties and is used in the manufacture of aniline and aniline colors.

CHAPTER XXIII.

BENZINE DERIVATIVES.

It is not necessary to point out a great many of the benzine derivatives but a comparatively few of them being of much importance. We have already seen that one or more of the benzine hydrogens may be replaced by halogen elements, hydroxyl, amidogen, acid radicals, hydrocarbon radicals, &c., hence it will be but necessary to consider the most important of these compounds thus formed by substitution.

There are but few HALOGEN SUBSTITUTIONS of importance and among them may be mentioned *mono-chlor benzine*, (C_6H_5Cl) and *mono iodo benzine* (C_6H_5I). Among the most important ACID DERIVATIVES of benzine is *nitro benzine* (C_6H_5, NO_2) formed by replacing the acid radical of nitric acid (the acid minus-hydroxyl) for one benzine hydrogen. It is prepared by adding nitric acid (HNO_3) to benzine and then precipitating the nitro-benzine by water. Thus produced

it is a heavy yellow oil with a pleasant odor—used in perfumery under the name of oil of merbane.

HYDROXYL SUBSTITUTIONS.

There are many important hydroxyl substitutions in benzene and the compounds thus produced are called *phenols*.

CARBOLIC ACID, C_6H_5OH .

Synonym. Phenol, hydroxyl benzene.

Occurrence. It is one of the principal constituents of coal tar from which it is prepared.

Properties. Carbolic acid crystallizes in clear needles but gradually turn red on exposure to the light. It has a peculiar dead smell, a sweetish taste and caustic properties. It is slightly soluble in water, readily in glycerine.

Uses. It is used in medicine as a disinfectant and in the production of aniline colors. Although phenol is really an alcohol it also acts as a mono-basic acid uniting with basic elements to form salts and with alcohol rests to form esters with the replacement of hydrogen.

Thus we have *sodium phenate* C_6H_5NaO .

lead phenate $(C_6H_5O)_2 Pb$, *phenyl ethyl ester* (C_6H_5O, C_2H_5) &c. If three of the benzene hydrogens are replaced by the acid radical NO_2 and one of the hydrogens by hydroxyl OH , there is formed **PICRIC ACID**, $C_6H_2(NO_2)_3OH$.

PICRIC ACID, $C_6H_2(NO_2)_3OH$.

Synonym. Tri-nitro-phenol.

Preparation. It is prepared by heating phenol with nitric acid (HNO_3).

Properties. Picric acid crystallizes in yellow leaves. It is soluble in water and has a very bitter taste. It forms salts with basic elements the most important of which is *potassium picrate* $C_6H_2(NO_2)_3KO$.

Uses. It is used for dyeing purposes.

If three benzene hydrogens are replaced by hydroxyl several isomeric compounds are produced the most important of which is *pyrogalllic acid* $C_6H_3(OH)_3$, a crystalline white substance soluble in water and with a bitter taste. It is a good oxidizing agent.

AMIDOGEN SUBSTITUTIONS.

Among the most important amidogen derivatives of benzene is aniline.

ANILINE, $C_6H_5NH_2$.

Synonym. Amido benzine.

Occurrence. It occurs largely in coal tar.

Preparation. It may be prepared in a number of ways as by the dry distillation of indigo, from coal tar by ignition, &c., but it is generally made by reducing nitro benzine ($C_6H_5NO_2$) with iron filing, and acetic acid ($C_2H_4O_2$) the reduction being thus represented :



Properties. Aniline is a yellowish liquid turning brown on exposure to the light. When brought in contact with calcium hypochlorite $Ca(ClO)_2$, it turns a violet color. It unites with acid to form salts.

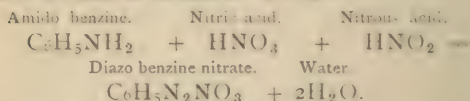
One or both of the amido hydrogens may be replaced by hydrocarbon radicals, forming compound anilines as *ethyl aniline* C_6H_5, NH, C_2H_5 ; or by acid rests as CHO , the acid rest of formic acid $CHO(OH)$, forming anilides as *formanilide* (C_6H_5, NH, CHO .)

Uses. It is used principally in the manufacture of aniline colors and dyes.

NITROGEN SUBSTITUTIONS.

AZO BENZINES. If hydrogen benzine be

replaced by nitrogen we have formed a group of compounds called *azo benzines*. The most important of these compounds are *azo benzine* $(C_6H_5)_2N$, *diazo benzine* $C_6H_5N_2$, and *diazo benzine nitrate* $C_6H_5N_2NO_3$, which is produced by the action of nitrous and nitric acid on amido benzine. Thus :—



This is a crystalline substance, decomposing with explosive violence on exposure to heat or percussion.

CHAPTER XXIV.

HYDROCARBON SUBSTITUTIONS OF BENZINE.

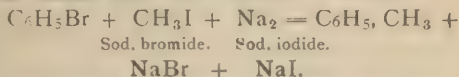
If one or more of the benzine hydrogens are replaced by hydrocarbon radicals a number of important compounds are formed and among them is—

TOLUENE, C_6H_5, CH_3 .

Synonym. Methyl benzine.

Preparation. It may be prepared by heating organic compounds to a high temperature, and then distilling, or chemically by heating mono brom-benzine and methyl iodine with sodium. Thus :—

Mono benzine. Meth. iod. Sodium. Toluene.



Properties. Toluene resembles benzine in all its properties.

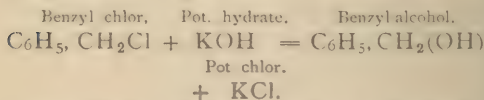
BENZYL COMPOUNDS.

One or more of the hydrogens in toluene may be replaced by halogens, hydroxyl, amidogen, &c., thus forming an

enormous number of new compounds, but the most important of which are those formed by replacing the hydrogen of the hydrocarbon radical in toluene—such substitutions are called *benzyl compounds*. By thus replacing one hydrogen with chlorine we have formed *benzyl chloride* C_6H_5, CH_2Cl , with hydroxyl *benzyl alcohol* C_6H_5, CH_2OH , &c.

BENZYL ALCOHOL, $C_6H_5, CH_2(OH)$.

Preparation. It is prepared by treating benzyl chloride with potassium hydrate. Thus:—



Properties. Benzyl alcohol is a colorless liquid with a pleasant odor. It forms esters by replacing the hydroxyl hydrogen with acid rests, as benzyl acetic ester C_6H_5, CH_2O, C_2H_3O , &c.

If two hydrogens in toluene instead of one be replaced by hydroxyl, a molecule of water is given off and *benzyl aldehyde* is formed.

BENZYL ALDEHYDE, C_6H_5, CHO .

Synonym. Benz aldehyde, bitter almond oil.

Preparation. It is prepared from a glucoside, occurring in bitter almonds called *amygdalin*.

Properties. It is a colorless liquid with the odor and taste of bitter almonds. It is not poisonous as the hydrocyanic acid (HCN), occurring in bitter almonds is eliminated by the process of preparation. If three hydrogens in toluene be thus replaced by hydroxyl *benzoic acid* is produced, a molecule of water being given off.

BENZOIC ACID, C_6H_5 , $CO(OH)$.

Occurrences. It occurs in many gums from which it is prepared by sublimation.

Properties. Benzoic acid crystallizes in colorless leaflets, slightly soluble in water and with an aromatic taste and odor. It is mono basic in character uniting with bases to form salts, as *sodium benzoate* $C_6H_5CO_2Na$.

CHAPTER XXV.

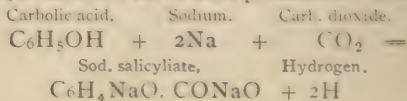
BENZOIC ACID DERIVATIVES.

One or more hydrogens in benzoic acid $C_6H_5CHO_2$ may be replaced by chlorine amidogen, hydroxyl, &c., thus forming a new set of compounds, many of which are important. Thus if one hydrogen is replaced by chlorine we have *mono chlor benzoic acid* (C_6H_4Cl, CHO_2); by NO_2 , *nitro benzoic acid* ($C_6H_4NO_2CHO_2$); by NH_2 , *amido benzoic acid* ($C_6H_4NH_2, CHO_2$); by OH , *Salicylic acid* (C_6H_4OH, CHO_2), &c.

SALICYLIC ACID, $C_6H_4(OH).CO(OH)$.

Occurrence. It occurs as a principal constituent of winter green oil.

Preparation. It is prepared from carbolic acid (C_6H_5OH) by heating it with sodium and then passing carbon dioxide through the mixture. In this way *sodium salicylate* $C_6H_4NaO.CONaO$ is also produced. Thus:



Properties. Salicylic acid crystallizes in prisms which are slightly soluble in water and having a bitter taste but no smell. It acts either as a mono or di basic acid uniting with alkalies with the replacement of both hydrogens as *sodium salicylate* $C_6H_4NaO_2$, $CONaO$.

Uses. It is used principally as an anti-septic and in medicine.

If three of the benzene hydrogens in benzoic acid are replaced by hydroxyl *gallic acid* is formed.

GALLIC ACID, $C_6H_2(OH)_3CHO_2$.

Preparation. It is usually prepared from its ester *tannic acid* ($C_{14}H_{10}O_6$.)

Properties. Gallic acid crystallizes in fine needles, is soluble in water and has a very bitter astringent taste.

Although it usually acts as a mono basic acid, any or all of the four hydroxyl hydrogens may be replaced by basic elements forming salts.

Tannic acid is an important ester of gallic acid.

TANNIC ACID, $C_{14}H_{10}O_9$.

Synonym. Tannin.

Occurrence. It occurs in many plants as nutgalls, sumach, &c., from which it is usually prepared by extraction with alcohol and ether.

Properties. Tannin is freely soluble in water has a very bitter taste and is astringent. Animal skins precipitate tannin from its solution converting them into leather.

HIPPURIC ACID, $C_9H_9NO_3$.

Occurrence. This acid is of complex composition, but is a derivative of benzoic acid. It occurs in the urine of herbivora and is the result of eating substances rich in benzoates.

Properties. Hippuric acid crystallizes in needles and is but slightly soluble in water.

It has a salty, bitter taste and is mono basic in character.

CHAPTER XXVI.

BENZINE DERIVATIVES (CONTINUED.)

We have so far considered only the hydrocarbon derivatives of benzine in which one hydrogen has been replaced.

Not only may one hydrogen be thus replaced, but hydrocarbon radicals may be substituted for two, three or four hydrogens, each forming a new set of compounds. But few of these compounds are of importance, many of them either not being understood or are unknown.

Those compounds resulting from the substitutions of hydrocarbon rests forming benzene derivatives with eight carbon atoms are called XYLENES from *xylene* $C_6H_4(CH_3)_2$; those forming benzene derivatives with nine carbon atoms CUMENS from *cumene* $C_6H_5(CH_3)$, and those containing ten carbon atoms CYMENES from *cymene* $C_6H_4(CH_3)_2$.

There are two *cumene* compounds which deserve attention, viz: *Cinnyl alcohol* and *cinnamic acid*, formed by replacing one of the

hydrogens in benzene with allyl alcohol (C_3H_5OH), and acrylic acid ($C_3H_4O_2$) respectively.

CYNNAL ALCOHOL, $C_6H_5, C_3H_4(OH)$

Synonym. Phenol allyl alcohol.

Properties. It is a colorless oil which gradually upon standing crystallizes into needles. It is but slightly soluble in water and upon oxidation is converted into CINNAMIC ALDEHYDE ($C_6H_5C_3H_3O$) a colorless liquid prepared from cinnamon oil which contains it largely.

CINNAMIC ACID, $C_6H_5, C_3H_2O(OH)$.

Occurrence. It occurs in liquid storax and separated from it by heating with sodium carbonate (Na_2CO_3). It also occurs in old cinnamon oil probably from oxidation of cinnamic aldehyde.

Properties. Cinnamic acid crystallizes in prisms which are soluble in water and have a bitter taste and pleasant odor. It has one replaceable hydrogen, hence is mono-basic, uniting with bases to form salts and with hydrocarbon rests to form esters.

INDIGO GROUP.

There is a class of compounds called the *indigo group* which are benzene derivatives,

but of complex composition. This group starts from a glucoside called *indican*, which occurs in a number of plants. This substance when boiled with acids decomposes into sugar and *indigo white*, and the latter by exposure to the air turns into *indigo blue*.

INDIGO BLUE, $C_{16}H_{10}N_2O_2$.

Preparation. It is best obtained in the pure state from commercial indigo, which consists of a number of substances, by sublimation.

Properties. Indigo blue is a blue, odorless and tasteless powder, insoluble in water and alcohol.

When heated with alkalis in presence of reducing agents as sulphuretted hydrogen (H_2S) it takes up hydrogen and passes into a soluble and colorless substance called *indigo white* ($C_{16}H_{12}N_2O_2$), which is largely used in indigo dyeing. On exposure to the air indigo white is slowly converted into indigo blue. Indigo blue when treated with oxidizing agents, as nitric or chromic acid, takes up oxygen and is converted into *isatin* ($C_{16}H_{10}N_2O_4$), which exists in the form of reddish brown, odorless

prisms slightly soluble in water, but readily in alcohol.

Both indigo blue and isatin when treated with potassium hydrate (KOH) are converted into aniline.

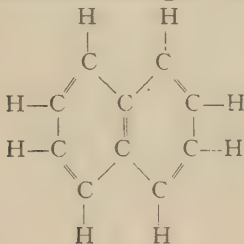
CHAPTER XXVII.

AROMATIC GROUPS OF ORGANIC COMPOUNDS.

We come now to the consideration of a number of important aromatic groups of compounds, some having their composition well known, while others have constitutions not known with certainty.

NAPHTHALINE GROUP.

This group has its starting point in *naphthaline* ($C_{10}H_8$), a substance occurring largely in coal tar. In composition it is a compound benzene; that is, formed by the union of two benzene rings. Thus:—



It crystallizes in white leaflets and has a peculiar odor and hot taste. It is but slightly soluble in water, but readily in alcohol.

One or more hydrogens may be replaced by halogens, acid radicals, hydroxyl, &c., thus forming naphthaline derivatives. The hydroxyl derivatives are called *naphthols* from *naphthol*, $C_{10}H_7(OH)$.

ANTHRACINE GROUP is derived from *anthracine* ($C_{14}H_{10}$), a substance also occurring largely in coal tar. It crystallizes in leaflets and is but slightly soluble in water.

ALIZARIN GROUP has its starting point in *alizarin* ($C_{14}H_8O_4$), a coloring matter obtained by fermenting the madder root and other plant roots.

It crystallizes in yellowish prisms, is insoluble in water, but readily in alkaline solution, from which it is precipitated by basic elements forming salts. It is used extensively in dyeing.

CAMPHOR GROUP. Common camphor ($C_{10}H_{16}O$) is the principal member of this group, and is obtained from the gum of the camphor tree. It is a gum-like substance, slightly soluble in water and readily in alco-

hol. It has a pleasant and burning taste, is combustible, burning with a very smoky, yellow flame. It unites directly with bromine without the replacement of hydrogen, forming brom-camphor ($C_{10}H_{16}Br_2O$.)

TURPENTINE GROUP. To this group belongs the *essential* oil, having the composition $C_{10}H_{16}$. They are obtained from plants by steam distillation and are usually divided into two groups, those containing oxygen and those free from oxygen. Among the former are *caraway oil*, *clove oil*, *rue oil*, *rose oil*, *bitter almond oil*, *anise oil*, &c.; while among the latter are *lemon oil*, *orange oil*, *turpentine oil*, *amber oil*, &c. There are also three essential oils containing sulphur, viz., *mustard oil*, *spoonwort oil*, and *leek oil*.

RESIN GROUP. Resins are obtained from plants together with the essential oil. If they remained dissolved in the essential oils they are called *balsams*, but if mixed with gum they are known simply as *resins*. Among the principal balsams may be mentioned *copaiba balsam*, *peru balsam*, *tolu balsam* and *shellac*.

Caoutchouc, or "india rubber" is one of the principal resins. It is obtained from

the juice of trees growing in India. When heated with sulphur it becomes "vulcanized" which renders it more elastic even when cold. On higher heating it is converted into "vulcanite" or "hard rubber." *Gutta percha* is a resin like india rubber and obtained in the same way.

Amber and *asphalt* are called the hard or "fossil" resins.

CHAPTER XXVIII.

ALKALOIDS.

Alkaloids are nitrogenous substances occurring in plants and sometimes called *organic bases* on account of their strong basic properties. They are almost insoluble in water but freely soluble in alcohol. They give soluble salts with acids. The alkaloids are precipitated from solutions of their salts with alkalies and tannic acid.

All the alkaloids contain carbon, nitrogen and hydrogen, some with, others without oxygen. When no oxygen is present the alkaloid is a liquid, but with oxygen they are mostly solid and crystalline.

Alkaloids are prepared by treating the powdered plants containing them with weak acids, and then distilling if the alkaloids are volatile. If not, the alkaloid bases are precipitated with alkalies from their acid solution.

The alkaloids all have a powerful action on the animal organism, hence are mostly poisonous and are used largely as medicines.

The following is a list of the most common alkaloids.

CONINE, $C_8H_{15}N$. Exists already formed in the hemlock.

NICOTINE, $C_{10}H_{14}N_2$. Obtained from tobacco leaves.

MORPHINE, $C_{17}H_{19}NO_3$.

CODEINE, $C_{18}H_{21}NO_3$.

NARCOTINE, $C_{22}H_{33}NO_7$, are all obtained with eighteen or nineteen others from the juice of the poppy (opium).

QUININE, $C_{20}H_{24}N_2O_2$, is obtained with three or four other alkaloids from the bark of the cinchona tree.

STRYCHNINE, $C_{27}H_{22}N_2O_2$, and BRUCINE $C_{23}H_{26}N_2O_4$ are both obtained from the seeds of the *strychnos nux vomica*.

ATROPINE, $C_{17}H_{23}NO_3$ is found in the deadly nightshade.

ACONITINE, $C_{38}H_{47}NO_7$ is found in the root of the purple monk's hood.

ESERINE, $C_{15}H_{21}N_8O_2$, and

PHYSOSTYGMINE are both obtained from the calabar bean.

COCAINE, $C_{17}H_{21}NO_4$ occurs in the leaves of the cocoa.

CHAPTER XXIX.

ANIMAL CHEMISTRY.

There are a number of complex substances, many of them with unknown composition occurring in animal tissues and fluids, and are hence usually described under the head of *animal chemistry*.

The organic compounds all contain oxygen, nitrogen, carbon and hydrogen, and some of them sulphur.

As these substances are properly treated of under physiology a mere mention of them will be given here.

Among these substances are albumen, fibrin, casein, &c., and may be classified under the following divisions :

INORGANIC SUBSTANCES.

Water, H_2O .

Sodium chloride, NaCl .

“ phosphate, Na_2HPO_4 .

“ bi-phosphate, NaH_2PO_4 .

“ sulphate, Na_2SO_4 .

“ carbonate, Na_2CO_3 .

Potassium chloride, KCl .

" phosphate, K_2HPO_4 .

" carbonate, K_2CO_3 .

" sulphate, K_2SO_4 .

Calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$.

" carbonate, CaCO_3 .

Magnesium phosphate, $\text{Mg}_3(\text{PO}_4)_2$.

" carbonate, MgCO_3 .

Besides these inorganic principles there is always found in larger or smaller amount in the animal tissues and fluids, traces of iron, silica and fluorine, these also are constant constituents.

HYDROCARBONS.

Glycogen, $\text{C}_7\text{H}_{11}\text{O}_5$.

Glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.

Lactose, $\text{C}_6\text{H}_{12}\text{O}_6$.

FATS.

Stearin, $\text{C}_3\text{H}_5(\text{C}_{18}\text{H}_{35}\text{O}_2)_3$.

Palmatine, $\text{C}_3\text{H}_5(\text{C}_{16}\text{H}_{31}\text{O}_2)_3$.

Olein, $\text{C}_3\text{H}_5(\text{C}_{18}\text{H}_{33}\text{O}_2)_3$.

Cholesterin, $\text{C}_{26}\text{H}_{44}\text{O}$.

Cholesterin is a crystalline substance found principally in the bile from which it sometimes crystallizes, forming gall stones.

It is also found in the blood, spleen, nerves, &c.

ALBUMINOUS PRINCIPLE.

These form an important group of substances found in the animal body, and all present the following peculiarities :

1st. They are, *hydroscopic*; second, they are *coagulable*, and third under favorable circumstances they undergo *putrefactive* changes.

Albumen, found principally in the plasma of the blood.

Casein, an albuminous principal in milk.

Fibrinogen, found in blood plasma.

Paraglabulin, obtained from the blood.

Myosine is obtained from muscular tissue, and causes "rigor mortis" by coagulation after death.

Syntonin or acid albumen produced by the action of the gastric juice on albumen.

Peptone, produced by the further action of gastric juice on albuminous matter.

Mucosine or "mucus," found in many glandular secretions.

Collagin, found in bones, tendons, &c., and yields "gelatine" on boiling.

Chondrine, albuminous principal in cartilage.

Elasticine, from yellow elastic tissue.

Keratine, an albuminous substance containing sulphur, found in hair, nails, &c.

ANIMAL FERMENTS,

There are substances that seem to cause by their presence *catalytic* transformations, that is, they produce changes in substances in which they come in contact without entering into chemical combination with them.

Ptyalin, ferment of the saliva.

Pepsin is the gastric juice ferment.

Pancreatin and *trypsin* the pancreatic ferments.

Fibrin or blood ferment causing the coagulation of the blood.

ANIMAL COLORING MATTER.

Hemoglobin, the coloring matter of the blood.

Melanin that of the skin, eyes, &c.

Bilirubin and *Biliverdin* that of the bile, and

Urochrome the coloring matter of the urine.

CRYSTALLIZABLE NITROGENOUS MATTER.

These substances differ from the albu-

minous principles by being crystallizable.
They are:

Lecithin, found in the blood, liver, &c.

Cerebrin, obtained principally from the brain and spinal cord.

Leucin, found largely in the spleen.

Sodium glycocholate and *Sodium taurocholate* are both ingredients of the bile.
Creatin, found principally in muscular tissue.

Creatinine, *urea*, *urates*, and *hippurates* are all found in the urine and are the result of tissue metamorphosis.

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